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MODERN LOW-MELTING BOROSILICATE GLASSES AND GLAZES FOR MAJOLICA AND POTTERY (A REVIEW)

V. V. Gerasimov[1] and O. V. Spirina[1]

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A review of low-melting borosilicate glasses and glazes for majolica and pottery is presented. The data given on the compositions and properties of glasses make it possible to identify a particular composition with the required properties and locate its patent source.

In view of the rapid progress of the modern construction industry, the requirements imposed on traditional silicate materials are becoming ever more stringent with respect to their quality and exterior parameters, which calls for the development of new materials with preset properties. The current trends echo the transition from mass-scale industrialized construction to individual buildings; consequently, current architecture is focused on artistic aspects, and the production volume of household and ornamental items is growing.

These goals can be reached using decorative facing ceramics, such as facing brick, glazed tile, roof tile, majolica, and pottery. Ceramics today has experienced a renaissance. Ceramic materials have an unlimited architectural potential and their properties provide for a number of advantages over other building materials.

However, the production of ceramic materials involves substantial power consumption, which runs counter to the energy strategy of Russia [1]. Nevertheless, the technologies of producing building ceramics are constantly being upgraded for the purpose of improving the consumer properties of ceramics and decreasing power consumption.

Low-melting glazes and glasses are rather popular in the ceramic industry, as they protect the surface of ceramic materials from contamination, the effect of acids and alkalis, the penetration of gases, and at the same time increase their strength and decorate their appearance.

A vast multitude of diverse glazes are known in the ceramic industry. They are classified based on different properties, such as firing temperature (*low-melting and high-melting glazes*), the production method (*raw and fritted*), application (*porcelain, faience, majolica, and pottery glazes*), composition (*feldspar, boric, boric-alkaline, and boric-lead*), exterior appearance (*lustrous, dull, and crystalline*), and translucence (*transparent and opaque*).

Low-melting glazes are complex multicomponent systems. Low-melting eutectics formed in such a system are less prone to devitrification (crystallization) than systems with a small number of components. An obligatory component in low-melting glazes is boric anhydride B_2O_3, which is an active glass-forming oxide and a strong flux increasing the luster, hardness, and thermal resistance of glazes. Most frequently B_2O_3 is introduced into a glaze composition in the form of boric acid or borax. Glaze is a silicate glass and, as any glass, consists of a disordered amorphous structure, which determines its main properties.

Glaze glasses are high-molecular inorganic systems containing ordered supermolecular structures [2]. Silicate radicals $[Si_mO_n]$ expand indefinitely in one, two, and three dimensions, forming a continuous pattern. [3]. The forces between the atoms in the radicals have a clearly polarized, directed, and covalent nature. These radicals disintegrate under melting into various complex polyions of a changing structure. The silica radicals in cooling combine with $[B_mO_n]$ radicals and form polymeric structures of mixed type. The fusibility of glass depends mainly on the degree of cross-linking of the polymeric skeleton and the type of its the modifying components.

A review of contemporary low-melting fritted borosilicate glasses and glazes for majolica and pottery with a firing temperature less than 1000°C is represented in the form of Table 1. These fine ceramics can be produced from local argillaceous materials and typically have a high artistic quality reflecting folk motifs. On the other hand, the drawbacks of majolica include its high porosity and water permeability and

[1] Kazan State Power University, Kazan, Russia; Kazan State Architecture and Construction Academy, Kazan, Russia.

TABLE 1

Composition, wt.% (molar content specified in brackets)	Properties	Specific features	Authors, source
56.95 – 62.65 SiO_2, 21.72 – 23.89 B_2O_3, 9.67 – 10.64 Na_2O, 5.96 – 8.52 K_2O (0.32 K_2O, 1.36 B_2O_3, 0.67 Na_2O, 4.29 SiO_2)	Melting temperature 1250 – 1300°C Firing temperature 870 – 1000°C TCLE (61.43 – 64.51) × 10^{-7} K^{-1} Thermal resistance 15 – 18 thermal cycles Luster 93 – 94% Resistance to cold 59 cycles	Increased firing interval	R. N. Nilevskaya, I. A. Levitskii, G. S. Balatskii, G. A. Terekhovich, V. V. Kozlov USSR Inventor's Certif. No. 1087482
53.62 SiO_2, 8 – 10 B_2O_3, 1 – 2 Na_2O, 28 – 37 CaO (0.06 Na_2O, 1.68 SiO_2, 0.94 CaO, 0.22 B_2O_3)	Whiteness 81 – 82%	–	G. M. Tunik, N. I. Belyusenko, L. L. Koshlyar USSR Inventor's Certif. No. 833640
57.8 – 59.3 SiO_2, 15.4 – 17.5 B_2O_3, 1.77 – 4.6 Al_2O_3, 0.01 – 0.04 CaO, 0.05 – 0.014 MgO (0.16 CaO, 0.1 Al_2O_3, 4 SiO_2, 0.84 MgO, 0.9 B_2O_3)	Firing temperature 900 – 950°C Exposure at the optimum firing temperature 2 h TCLE (48 – 51) × 10^{-7} K^{-1} Spreadability 112 – 118 mm	Increased spreadability of the coating Decreased firing temperature Increased firing interval	R. N. Milevskaya, I. A. Levitskii, G. A. Terekhovich USSR Inventor's Certif. No. 962231
48.1 – 53.9 SiO_2, 10.14 – 15.6 B_2O_3, 21.2 – 3.6 ZnO, 5.56 – 9.09 Na_2O, 4.6 – 8.98 ZrO_2 (0.33 Na_2O, 2 SiO_2, 0.67 ZnO, 0.45 B_2O_3, 0.13 ZrO_2)	Firing temperature 900 – 980°C TCLE (4.5 – 5.0) × 10^{-7} K^{-1} Whiteness 87 – 89% Resistance to cold greater than 50 cycles	Increased whiteness Decreased content of scarce compounds	N. M. Bobkova, S. A. Gailevich, O. G. Gorodetskaya, Ya. I. Moiseeva USSR Inventor's Certif. No. 1004284
60.57 – 65.25 SiO_2, 3.97 – 7.91 Al_2O_3, 16.3 – 24.43 B_2O_3, 6.7 – 7.74 Na_2O, 2.92 – 4.36 K_2O	Firing temperature 860 – 950°C TCLE (43 – 46) × 10^{-7} K^{-1} Thermal resistance 250 – 260°C Chemical resistance 99%	Transparent glaze	N. M. Bobkova, I. A. Levitskii, V. I. Rusak, R. N. Milevskaya USSR Inventor's Certif. No. 1025679
58 – 63 SiO_2, 6 – 12 Al_2O_3, 20 – 28 RO (RO · 0.3Al_2O_3 · 3.3SiO_2)	Melting temperature 1280 – 1450°C Melting duration 20 – 40 min Firing temperature 1170 – 1260°C	Smooth surface High heat resistance	Matsuyama Sirokhito Japan patent application 59-88337
48 – 60 SiO_2, 10.5 – 12.5 B_2O_3, 7 – 11 Al_2O_3, 9 – 10.15 Na_2O, 8 – 10 CaO, 2.5 – 4.5 BaO (0.5 Na_2O, 4.8 SiO_2, 0.4 CaO, 0.3 Al_2O_3, 1.3 B_2O_3, 0.1 BaO)	TCLE (53 – 54) × 10^{-7} K^{-1} Microhardness 75 – 80 MPa	Increased microhardness Chemical resistance Increased adhesion to ceramics	N. M. Bobkova, S. A. Gailevich, S. A. Yankovskaya, G. N. Khrul', T. P. Tupai USSR Inventor's Certif. No. 1038304
56.9 – 62.9 SiO_2, 15.6 – 23.7 B_2O_3, 3.77 – 7.6 Al_2O_3, 1.34 – 2.8 K_2O, 7.34 – 8.43 Na_2O, 3.59 – 5.9 TiO_2 (0.14 K_2O, 0.3 Al_2O_3, 86 Na_2O, 6.4 SiO_2, 1.65 B_2O_3, 0.33 TiO_2)	Melting temperature 1280 – 1300°C Firing temperature 760 – 980°C Exposure at the firing temperature 2 h TCLE (50.98 – 53.69) × 10^{-7} K^{-1} Softening temperature 445 – 490°C Spreading start temperature 940 – 980°C Whiteness 12 – 15%	Decreased firing temperature Increased heat resistance and whiteness	N. M. Bobkova, V. I. Rusak, I. A. Levitskii USSR Inventor's Certif. No. 1004285
58.3 – 64.95 SiO_2, 3.76 – 7.61 Al_2O_3, 15.22 – 20.78 B_2O_3, 7.20 – 7.41 Na_2O, 2.75 – 2.81 K_2O, 3.09 – 6.12 SrO (0.3 K_2O, 0.54 Al_2O_3, 0.7 Na_2O, 1.1 SiO_2, 0.27 B_2O_3)	Melting temperature 1320 – 1350°C Firing temperature 890 – 980°C Exposure 2 h Thermal resistance 230 – 315°C Spreadability 86 – 93 mm Contact wetting angle 70 – 73°	Increased heat resistance and spreadability	N. M. Bobkova, I. A. Levitskii, R. N. Milevskaya USSR Inventor's Certif. No. 1090669
12.5 – 14.5 SiO_2, 37 – 40 B_2O_3, 25 – 27.5 ZnO, 6.5 – 7 ZrO_2, 5 – 10 CuO, 4 – 11 V_2O_5 (0.8 ZnO, 1 V_2O_5, 0.6 SiO_2, 0.2 CuO, 1.4 B_2O_3, 0.1 ZrO_2)	Firing temperature 700°C TCLE (30.6 – 41.5) × 10^{-7} K^{-1}	–	L. M. Silich, L. G. Yasinskii, V. I. Shamkalovich, I. N. Savelov USSR Inventor's Certif. No. 1060586

TABLE 1. (*Continued*)

Composition, wt.% (molar content specified in brackets)	Properties	Specific features	Authors, source
40.42 – 48.28 SiO_2, 20.97 – 26.19 B_2O_3, 8.83 – 12.28 Al_2O_3, 8.43 – 12.28 CaO, 4.5 – 6.25 Na_2O, 3.63 – 7.24 ZrO_2 (0.7 CaO, 0.4 Al_2O_3, 3 SiO_2, 0.3 Na_2O, 1.3 B_2O_3, 0.16 ZrO_2)	Melting temperature 1200 – 1250°C Firing temperature 800 – 820°C TCLE (52 – 54) × 10^{-7} K^{-1} Thermal resistance 225 – 250°C Luster 76 – 78% Whiteness 93 – 96%	Decreased melting and firing temperature Increased heat resistance and whiteness	N. M. Bobkova, É. V. Apanovich, S. A. Gailevich, A. A. Stepanchuk USSR Inventor's Certif. No. 1098919
40 – 50 SiO_2, 25 – 28 B_2O_3, 3 – 5 Al_2O_3, 3 – 4 K_2O, 4 – 6 Na_2O, 12 – 15 CaO (0.17 K_2O, 2.16 SiO_2, 0.23 Na_2O, 0.12 Al_2O_3, 1.1 B_2O_3, 0.7 CaO)	Melting temperature 1300°C Firing temperature 840 – 920°C TCLE (52.1 – 53.2) × 10^{-7} K^{-1} Thermal resistance 280°C Luster 78 – 79%	Increased heat resistance	N. M. Bobkova, A. A. Stepanchuk, S. A. Gailevich USSR Inventor's Certif. No. 1119993
57.3 – 67.2 SiO_2, 14.4 – 16.5 B_2O_3, 1.7 – 3.1 CaO, 9.7 – 12.4 ZnO, 3.6 – 5.5 Na_2O, 3.4 – 5.2 ZrO_2 (0.3 Na_2O, 4 SiO_2, 0.1 CaO, 0.6 B_2O_3, 0.6 ZnO, 0.15 ZrO_2)	Melting temperature 1300 – 1350°C Firing temperature 900 – 950°C TCLE (51 – 55) × 10^{-7} K^{-1} Thermal resistance 210 – 220°C Microhardness 71 – 72 MPa Abradability 0.05 g/cm^2 Luster 42 – 46% Whiteness 94% Resistance to cold 80 cycles	Increased resistance to cold Thermal resistance Production of defect-free glaze coating	N. M. Bobkova, O. G. Gorodetskaya, S. A. Gailevich USSR Inventor's Certif. No. 1119992
27 – 33 SiO_2, 7 – 9 B_2O_3, 39 – 46 Bi_2O_3, 4 – 7 ZnO, 3 – 8 BaO, 1 – 3 TiO_2, 4 – 12 CuO (0.38 ZnO, 2.1 SiO_2, 0.42 CuO, 0.7 Bi_2O_3, 0.5 B_2O_3, 0.2 BaO, 0.1 IrO_2)	Softening temperature 367 – 372°C TCLE (80 – 83) × 10^{-7} K^{-1} Density 6.2 – 6.4 g/cm^3	Decreased softening temperature	M. D. Shcheglova, É. Ya. Berkovskaya USSR Inventor's Certif. No. 945107
58 – 65 SiO_2, 12.5 – 19.5 B_2O_3, 5.5 – 10 Al_2O_3, 5.5 – 10.5 Na_2O, 1.5 – 2.5 BaO, 1.5 – 3 MgO, 1.5 – 3.5 ZrO_2 (0.1 Na_2O, 0.89 SiO_2, 0.8 MgO, 0.1 Al_2O_3, 0.2 B_2O_3, 0.1 BaO)	Melting temperature 1400 – 1450°C Fusing temperature 1000 – 1050°C TCLE (55 – 56) × 10^{-7} K^{-1} Thermal resistance 220°C Resistance to cold 50 cycles	Increased whiteness and viscosity	N. M. Bobkova, O. G. Gorodetskaya, S. A. Yankovskaya USSR Inventor's Certif. No. 962229
5.5 – 14.5 SiO_2, 28 – 42 B_2O_3, 32.5 – 42.5 PbO, 3 – 7.5 ZnO, 3 – 5 CuO, 2.5 – 4 V_2O_5, 4.4 – 5.5 ZrO_2 (0.6 PbO, 0.05 Al_2O_3, 0.7 SiO_2, 0.22 ZnO, 0.03 V_2O_5, 1.75 B_2O_3, 0.18 CuO, 0.14 ZrO_2)	Firing temperature 690 – 720°C Softening temperature 480 – 510°C Spreading temperature 610 – 660°C	Decreased TCLE	L. M. Silich, L. G. Yasinskii, V. I. Shamkalovich, I. N. Savelov USSR Inventor's Certif. No. 975622
37 – 45 SiO_2, 25 – 30 B_2O_3, 2.5 – 5 Al_2O_3, 6 – 15 CaO, 2.5 – 11 ZnO, 1 – 5 Na_2O, 5 – 10 K_2O (0.16 CaO, 0.73 ZnO, 0.03 Al_2O_3, 0.7 SiO_2, 0.04 Na_2O, 0.3 B_2O_3, 0.07 K_2O)	Melting temperature 1300 – 1350°C Firing temperature 850 – 920°C TCLE (60.8 – 69) × 10^{-7} K^{-1} Thermal resistance 12 thermal cycles Resistance to cold 60 cycles	Increased resistance to cold	N. M. Bobkova, S. A. Gailevich, A. A. Stepanchuk, S. A. Yankovskaya USSR Inventor's Certif. No. 1044609
45.3 – 55.5 SiO_2, 13.2 – 23 B_2O_3, 6.2 – 15.6 Al_2O_3, 3.3 – 9 CaO, 3.4 – 7.4 Na_2O, 2.2 – 5.3 K_2O, 3.3 – 7.3 MgO (0.23 CaO, 0.26 Na_2O, 0.32 Al_2O_3, 2.5 SiO_2, 0.11 K_2O, 0.7 B_2O_3, 0.4 MgO)	Melting temperature 1200 – 1250°C Firing interval 820 – 850°C TCLE (51 – 53) × 10^{-7} K^{-1} Chemical resistance 3.26% Thermal resistance 10 thermal cycles Luster 92%	Decreased TCLE Increased luster and acid resistance	N. M. Bobkova, S. A. Gailevich USSR Inventor's Certif. No. 1025671
44.5 – 52.6 SiO_2, 14 – 18.5 B_2O_3, 7.1 – 12 Al_2O_3, 0.1 – 2.0 SrO, 10.9 – 15.5 CaO, 8.6 – 11.9 K_2O, 0.1 – 0.9 MoO_3 (0.02 SrO, 0.23 Al_2O_3, 2 SiO_2, 0.6 CaO, 0.6 B_2O_3, 0.3 K_2O, 0.08 MoO_3)	Melting temperature 1250°C Firing temperature 960°C TCLE 65 × 10^{-7} K^{-1} Whiteness 82%	Increased whiteness	Ya. K. Klivin'sh, A. P. Raman, P. G. Pauksh, M. M. Miezis, M. L. Grinberg, Yu. Ya. Éiduk USSR Inventor's Certif. No. 1052481

TABLE 1. (*Continued*)

Composition, wt.% (molar content specified in brackets)	Properties	Specific features	Authors, source
48 – 52 SiO_2, 2.4 – 8 B_2O_3, 20 – 31 Al_2O_3, 8 – 10 CaO, 6 – 8 MgO, 2 – 4 BaO, 1 – 2 Na_2O (0.42 CaO, 0.65 Al_2O_3, 0.08 Na_2O, 2.16 SiO_2, 0.05 BaO, 1.93 B_2O_3, 0.45 MgO)	No data	Ensuring the process of glaze coating formation in a reducing medium	L. N. Trushkova, V. V. Troshin, R. D. Zhukovskaya USSR Inventor's Certif. No. 1071586
35 – 39 SiO_2, 35 – 37 B_2O_3, 5 – 10 Al_2O_3, 3.5 – 5 CaO, 2 – 10 BaO, 2 – 4.9 Na_2O, 1.5 – 5 K_2O (0.23 K_2O 0.37 CaO, 0.3 Al_2O_3, 2.17 B_2O_3, 0.24 Na_2O, 2.6 SiO_2, 0.16 BaO)	Melting temperature 1400°C Firing temperature 800 – 850°C TCLE (46 – 47) × 10^{-7} K^{-1} Luster 93%	Decreased TCLE	V. I. Rusak, A. G. Smolonoka, N. I. Vidmand, T. K. Vidmand, T. I. Mikhal'skaya USSR Inventor's Certif. No. 1079619
49.5 – 54 SiO_2, 24 – 27.5 B_2O_3, 4 – 6 Al_2O_3, 4 – 6 CaO, 0.5 – 1 MgO, 4 – 6 BaO, 5.5 – 8 Na_2O (0.4 CaO, 0.1 MgO, 0.2 Al_2O_3, 3.5 SiO_2, 0.2 BaO, 1.5 B_2O_3, 0.3 Na_2O)	Firing temperature 1000 – 1020°C TCLE 6.7 × 10^{-6} K^{-1} Thermal resistance 170 – 200°C	Improved quality of coating	G. B. Obukhova, I. I. Ryshchenko, V. A. Goncharov, L. F. Kochura USSR Inventor's Certif. No. 1089068
2.78 – 3.2 SiO_2, 1.1 – 1.5 B_2O_3, 0.24 – 0.35 Al_2O_3, 0.25 – 0.44 CaO, 0.1 – 0.17 BaO, 0.25 – 0.3 Na_2O, 0.12 – 0.2 K_2O	Firing temperature 820 – 890°C TCLE (6.83 – 6.92) × 10^{-6} K^{-1} Melting duration 45 min	Ensuring transparency Decreased fusing duration Decreased melting temperature and TCLE	Ingeborg Sheler USSR Inventor's Certif. No. 722863 Imano Shigeishi, Sato Ukira Japan patent application 56-78448
47.8 – 57.6 SiO_2, 11.2 – 15.8 Al_2O_3, 5 – 6.4 B_2O_3, 0.5 – 0.6 Fe_2O_3, 0.6 – 0.8 CaO, 0.2 – 0.3 MgO, 15.5 – 21.6 Na_2O, 7.8 – 9.1 F	Firing temperature 750 – 800°C	Increased thermal resistance and mechanical strength	I. G. Khizanishvili, A. A. Aizenberg, Sh. A. Dzhaparidze USSR Inventor's Certif. No. 416322
50.2 – 54.6 SiO_2, 5.4 – 7.1 Al_2O_3, 15.3 – 17.6 B_2O_3, 4 – 5.8 CaO, 0.4 – 1.0 MgO, 0.8 – 1.2 ZnO, 5.1 – 6 Na_2O, 0.8 – 1.5 BaO, 9.5 – 11.4 ZrO_2	Melting temperature 1400°C Firing temperature 950 – 970°C TCLE (48 – 52) × 10^{-7} K^{-1}	Decreased TCLE Ensuring a high degree of whiteness	K. K. Kvyatkovskaya USSR Inventor's Certif. No. 383698
40.2 – 48.3 SiO_2, 3 – 5 Al_2O_3, 35.8 – 39.6 B_2O_3, 6.5 – 8.5 Na_2O, 1.5 – 1.7 K_2O, 2.4 – 3 CaO, 0.7 – 0.9 MgO, 0.3 – 0.5 CuO, 1.5 – 1.7 SnO_2	Firing temperature 900 – 950°C Microhardness 547 – 579 kg/mm^2 Resistance to cold 81 – 85 cycles	Increased fusibility	S. S. Takibaeva, G. I. Shulgaubaeva USSR Inventor's Certif. No. 833634
57.2 – 62.1 SiO_2, 6.1 – 8.6 Al_2O_3, 12.6 – 13.5 Fe_2O_3, 3.3 – 5.2 ZnO, 3.1 – 5.5 CaO, 0.2 – 1.2 MgO, 2.4 – 4.1 K_2O, 1.1 – 1.9 Na_2O, 2.5 – 4.6 GeO_2	Melting temperature 1250°C Firing temperature 950°C TCLE (59.6 – 61.7) × 10^{-7} K^{-1}	Decreased firing temperature	A. A. Novospashin, T. B. Arbuzova, D. A. Romanyuk USSR Inventor's Certif. No. 814916
53.1 – 56.5 SiO_2, 9.8 – 10.4 B_2O_3, 11.7 – 12.2 Al_2O_3, 0.3 – 0.36 Fe_2O_3, 0.51 – 0.54 CaO, 12 – 12.7 Na_2O, 2.46 – 2.6 K_2O, 3 – 5 CuO, 0.5 – 5 Cr_2O_3	Firing temperature 950°C Firing duration 3 h TCLE (60 – 62.5) × 10^{-7} K^{-1} Microhardness 680 – 686 kg/mm^2	Increased luster	E. Sh. Kharashvili, L. V. Mgaloblishvili USSR Inventor's Certif. No. 981268
41 – 51 SiO_2, 8 – 10 Al_2O_3, 10 – 17 B_2O_3, 4 – 6 ZnO, 0.02 – 0.5 Fe_2O_3, 3 – 8 CaO, 0.03 – 0.5 MgO, 6 – 10 Na_2O, 1 – 3 K_2O, 8 – 11 ZrO_2	Firing temperature 820 – 860°C Whiteness 89 – 90% Mohs hardness 6 – 7	Increased whiteness	N. V. Kulikova, O. V. Privezentseva USSR Inventor's Certif. No. 833630
37 – 39 SiO_2, 5 – 6.5 Al_2O_3, 18.6 – 21.5 B_2O_3, 10 – 13 SrO, 2.5 – 4.2 ZnO, 0.5 – 1.5 MgO, 3 – 7.1 Na_2O, 2.6 – 4 K_2O, 8 – 10 CaO, 2 – 3.5 F	Firing temperature 900 – 920°C TCLE (67 – 73) × 10^{-7} K^{-1} Whiteness 79 – 80%	Decreased viscosity Increased whiteness	A. S. Krasnousova, T. S. Solnyshkina USSR Inventor's Certif. No. 833637

insufficient bending strength, which restricts its application area. However, a low-melting glaze used as a vitreous coating on a majolica or pottery product can eliminate these drawbacks and impart an attractive appearance to the surface of the product. Furthermore, tinted glazes can conceal the defects of majolica and pottery acquired in firing (a change of color or chips).

The glazes in Table 1 are arranged in the order of growing complexity of their compositions. In view of the toxicity and scarcity of lead, the current trend is to completely stop the use of lead oxides in glazes; therefore, low-melting lead glazes are not listed. Table 1 specified the main technological and physicotechnical properties of glasses. Particular attention is paid to the specific features of glasses used as coatings on ceramics (their spreadability, adhesion to the substrate, firing interval, and chemical resistance).

Ceramic technologists widely use the Seger formula for calculating composition and classifying glazes, according to which all oxides making up glazes are split into three groups: alkali and alkaline-earth R_2O and RO (Na_2O, K_2O, CaO, MgO), neutral R_2O_3 (Al_2O_3), and acid RO_2 (SiO_2). Furthermore, the group of acid oxides includes boric anhydride B_2O_3.

In calculations using the Seger formula the oxides are represented as molar fractions, whereas the sum of the alkali and alkaline-earth oxides is reduced to unity, and the basic and acid oxides are expressed in molar fractions per 1 mole of alkali and alkaline-earth oxides.

Accordingly all glaze compositions should satisfy the formula

$$1(R_2O + RO) \cdot mR_2O_3 \cdot nRO_2.$$

The Seger formula provides for a clear representation of a complex glaze composition and creates a basis for the classification of glazes according to their chemical compositions.

Low-melting glazes have the following formula:

$$1(R_2O + RO)(0.1 - 0.3)R_2O_3(1 - 3)RO_2.$$

We have calculated molecular formulas for several glaze glasses, which makes it possible to predict the probable properties of the glazes proposed.

The low-melting borosilicate glasses listed in Table 1 structurally have a lot in common and differ only in the degree of cross-linking of the silica skeleton. Researchers developing glazes in fact just control the ratio between the polymer-forming and the modifier elements. Several cations, mainly the multi-charge ones, perform both of these structural functions.

The data supplied on the compositions and properties of low-melting glasses and glazes make it possible to identify a particular composition with the required properties and locate its source.

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